REMARKS

This is in response to the Office Action mailed on June 19, 2006, in which claims 1, 3-12, 14-17 and 29-38 were rejected. With this Amendment, claim 29 is amended and claim 33 is canceled. As discussed below, Applicant believes the application is now in condition for allowance and and requests that 1, 3-12, 14-17 and 29-38 be allowed.

I. Rejections Under 35 U.S.C. 102

A. Claims 1, 3 and 5-10

Claims 1, 3 and 5-10 stand rejected under 35 U.S.C. 102(e) as being anticipated by Kreupl (U.S. 6,777,731). Independent claim 1 claims a tunneling magnetoresistive (TMR) stack that includes first and second ferromagnetic layers and a tunnel barrier layer "wherein the tunneling magnetoresistive stack exhibits a negative exchange coupling between the first ferromagnetic layer and the second ferromagnetic layer." Claim 1 is patentable because a TMR with *negative* exchange coupling is not disclosed in Kreupl.

"Exchange coupling" is a well-known quantum mechanical phenomenon which is characterized by a shifted hysteresis loop. Examples of shifted hysteresis loops are shown in Fig. 3 and Fig. 5 of the present application. Positive exchange coupling is characterized by a hysteresis loop that is shifted to the right of the origin (such as the loop shown in Fig. 3), while negative exchange coupling is characterized by a hysteresis loop that is shifted to the left of the origin (such as the loop shown in Fig. 5).

In a traditional spin valve or TMR stack, positive exchange coupling exists between the fixed layer and free layer. When an external magnetic field is applied to a traditional TMR stack, the magnetization direction of the free layer will not rotate until the applied magnetic field is strong enough to overcome the positive exchange coupling between the free layer and pinned layer. For example, in Fig. 3 of the application, which shows the shifted hysteresis loop of positive exchange coupling, as an external magnetic field is applied (moving to the right along the x-axis) the free layer will resist changing its magnetic orientation until the applied magnetic field reaches point H_{EX}. After that point, the free layer will begin to

shift its orientation to align with the applied magnetic field (shown as 18 in Fig. 3).

In contrast, the invention of claim 1 claims *negative* exchange coupling between the first and second ferromagnetic layers. Fig. 5 of the application shows the shifted hysteresis loop that is characteristic of negative exchange coupling. With negative exchange coupling, the hysteresis loop is shifted to the left of the origin, rather than to the right.

Claim 1 has been rejected as being anticipated by Kreupl (U.S. 6,777,731). Kreupl is said to disclose negative exchange coupling between first and second ferromagnetic layers because "the magnetization direction of the memory layer 3 is directed in the same direction as or in the opposite direction to the magnetization of the reference layer 5, depending on the data content of the memory cell 1." (Kreupl, col. 11, lines 33-36). According to the Office Action, "as the magnetization direction of the layer 3 is directed in the opposite direction to the magnetization of layer 5, there exhibits a negative exchange coupling between these two layers." This is incorrect. Kreupl does not disclose negative exchange coupling.

Negative exchange coupling is not exhibited merely by having two layers that have opposite magnetic orientations. Materials exhibiting positive exchange coupling may also have opposite orientations after application of an applied field, such as the write current that creates the 'data content' of memory cell 1 in Kreupl. Thus, Kreupl discloses nothing more than the prior art that is explicitly discussed in the application. Kreupl appears to disclose a TMR with positive exchange coupling, but there is nothing in Kreupl that discloses, teaches or suggests a TMR with *negative* exchange coupling between ferromagnetic layers. The claiming of negative exchange coupling in claim 1 makes it patentably distinct from Kreupl.

Because Kreupl does not disclose negative exchange coupling, Applicant respectfully requests that claim 1 be allowed. Similarly, since claims 3-9 are dependent claims that depend from claim 1, those claims are also allowable. Reconsideration and allowance of claims 1 and 3-9 is respectfully requested.

B. Claims 11, 12 and 14-16

Claims 11, 12 and 14-16 also stand rejected under 35 U.S.C. 102(e) as being anticipated by Kreupl (U.S. 6,777,731). Independent claim 11, like claim 1, also claims first and second ferromagnetic layers and negative exchange coupling between the first and second ferromagnetic layers. As discussed in detail in the preceding section, Kreupl does not disclose, teach or suggest negative exchange coupling. Consequently, claim 11 is patentable over Kreupl. Also, claims 12 and 14-16 are dependent claims that depend on claim 11, and those claims are also patentable over Kreupl. Reconsideration and allowance of claims 11, 12 and 14-16 is respectfully requested.

II. Rejections Under 35 U.S.C. 103

A. Claims 29-35 and 37-38

Claims 29-35 and 37-38 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Kreupl. Independent 29 includes first and second ferromagnetic layers that have opposite magnetization directions "in the absence of an applied magnetic field." Also, claim 29 has also been amended to indicate that the opposite magnetization directions in the absence of an applied magnetic field result from negative exchange coupling. As discussed in detail with respect to claim 1, Kreupl discloses a traditional TMR in which the magnetic orientation of the fixed and free layers have the same magnetic orientation in the absence of an applied magnetic field. There is nothing in Kreupl that discloses, teaches or suggests first and second ferromagnetic layers having opposite magnetization directions from negative exchange coupling in the absence of an applied magnetic field.

Because Kreupl does not disclose first and second ferromagnetic layers having opposite magnetization directions in the absence of a magnetic field resulting from negative exchange coupling, claim 29 is patentable over Kreupl. Similarly, since claims 30-35 and 37-38 are dependent claims that depend upon claim 29, those claims are also patentable over Kreupl. Reconsideration and allowance of claims 29-35 and 37-38 is respectfully requested.

B. Claims 4, 17 and 36

Claims 4, 17 and 36 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Kreupl in view of Chen et al. (U.S. 6,138,859). Claims 4, 17 and 36 are dependent claims that depend from independent claims 1, 11 and 29, respectively. As discussed in detail above, each of these claims include negative exchange coupling between two ferromagnetic layers, which is not disclosed, taught or suggested by Kreupl. Therefore, reconsideration and allowance of claims 4, 17 and 36 is respectfully requested.

C. Claims 1, 3, 5-16, 29-35 and 37-38

Claims 1, 3, 5-16, 29-35 and 37-38 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Parkin (U.S. 5,764,567) in view of Carey et al. (U.S. 6,756,128). As noted above, claims 1, 11 and 29 are the three independent claims in this application. All of those claims include negative exchange coupling between two ferromagnetic layers and a barrier material made of a titanium alloy oxide (claims 1 and 11) or an oxide, nitride or oxynitride of a titanium alloy (claim 29). While some of the claim elements may arguably be disclosed in each of Parkin and Carey et al., there is no teaching, suggestion or motivation to combine these references, and Parkin even teaches away from such a combination.

Parkin discloses a magnetic tunneling junction (MTJ) device with a non-ferromagnetic interface 31 inserted between the tunneling layer and one of the ferromagnetic layers in order to increase the distance between the two ferromagnetic layers. The non-ferromagnetic interface is made of a metal like Al, Cr, Pt, Au, Ag or Cu. In describing the problem solved by his invention, Parkin describes a traditional MTJ device with an Al_2O_3 tunneling barrier (Fig. 3) that displays a hysteresis loop with a small negative shift (Fig. 5). Parkin attributes this phenomenon to "roughness" in the barrier material (Parkin, col. 7, line 66) resulting in interaction between the two ferromagnetic layers (Parkin, col. 7, lines 25-30). This negative shift of the hysteresis loop degrades the performance of the MTJ device (Parkin, col. 8, lines 13-15), and Parkin's invention is designed to reduce or eliminate this interaction between the two ferromagnetic layers (Parkin, col. 9, lines 18-27; Figs. 8A-8C).

Thus, Parkin teaches away from the present invention. He discloses a MTJ device with an Al_2O_3 tunneling barrier and undesirable negative exchange coupling between the fixed and free ferromagnetic layers. His invention seeks to eliminate the negative exchange coupling between the ferromagnetic layers. Parkin, of course, does not disclose any tunneling barriers made from titanium alloy oxides, nitrides or oxynitrides.

Carey et al. discloses a TMR with a titanium oxynitride (TiO_xN_y) barrier material to reduce RA and increase magnetoresistance. Carey et al. mentions alloying the TiO_xN_y material to produce a $TiAlO_xN_y$ barrier material, but does not disclose using TiO_x or $TiAlO_x$ barrier materials. Nor does Carey et al. disclose negative exchange coupling between two ferromagnetic layers separated by a tunneling barrier.

Obviousness cannot be established by combining prior art references to produce the claimed invention unless there is some teaching, suggestion or motivation to combine the references, either in the references themselves, in knowledge generally available to one skilled in the art, or the nature of the problem to be solved. *In re Kotzab*, 217 F.3d 1365, 1370, 55 USPQ2d 1313, 1316-17 (Fed. Cir. 2000). There is no teaching, suggestion or motivation in either Parkin or Carey et al. to combine the $TiAlO_xN_y$ barrier material disclosed in Carey et al. to create negative exchange coupling between ferromagnetic layers, which Parkin sought to eliminate.

Prior art must be considered as a whole, including portions that would lead away from the invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ2d 303 (Fed. Cir. 1983). Parkin teaches that negative exchange coupling is an undesirable characteristic in a MTJ device. Thus, one skilled in the art would not consider it obvious to utilize barrier materials like those disclosed by Carey et al. to create negative exchange coupling.

Because there is no teaching, suggestion or motivation to combine Parkin and Carey et al., and because Parkin teaches away from the invention, claims 1, 3, 5-16, 29-35 and 37-38 are patentable over Parkin and Carey et al. Reconsideration and allowance of claims 1, 3, 5-16, 29-35 and 37-38 is

respectfully requested.

III. Conclusion

In view of the foregoing, this application containing pending claims 1, 3-12, 14-17 and 29-38 is in condition for allowance. Reconsideration and notice to that effect is respectfully requested.

Respectfully submitted,

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